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How social information affects information search and choice in probabilistic inferences

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Abstract

When making decisions, people are often exposed to relevant information stemming from qualitatively different sources. For instance, when making a choice between two alternatives people can rely on the advice of other people (i.e., social information) or search for factual information about the alternatives (i.e., non-social information). Prior research in categorization has shown that social information is given special attention when both social and non-social information is available, even when the social information has no additional informational value. The goal of the current work is to investigate whether framing information as social or non-social also influences information search and choice in probabilistic inferences. In a first study, we found that framing cues (i.e., the information used to make a decision) with medium validity as social increased the probability that they were searched for compared to a task where the same cues were framed as non-social information, but did not change the strategy people relied on. A second and a third study showed that framing a cue with high validity facilitated learning to rely on a non-compensatory decision strategy. Overall, the results suggest that social in comparison to non-social information is given more attention and is learned faster than non-social information.

Key words: Probabilistic inference; Social influence; Decision making; Attention; Information search

PsycINFO classification

2300 Experimental Psychology

2340 Cognitive Process

2343 Learning & Memory

1 Introduction

In everyday life people can access information from social and non-social sources when making a decision: Suppose you are hiring a new employee. You might make an informed decision by reading the applicant's resume, by consulting prior employers, or simply by asking your colleagues for advice. There is good reason to believe that besides the validity of a piece of information the source of the information also influences whether it is looked up or not. Previous research suggests that social information such as advice receives more attention than non-social information of the same validity because people are inherently biased towards acquiring, remembering and transmitting social information (Heyes, 2012; Mesoudi, Whiten, & Dunbar, 2006). Accordingly, social information is frequently considered (Drehmann, Oechssler, & Roider, 2007; Gibson, 2004), even when non-social information is available (Smith & Collins, 2009; Sommerfeld, Krambeck, Semmann, & Milinski, 2007). Consistently, research in categorization has found that people adhere to social information even if it carries no additional informative value (Collins, Percy, Smith, & Kruschke, 2011; Puskaric, von Helversen, & Rieskamp, 2016). The goal of the current research is to investigate whether framing information as social or non-social also influences information search and decision making in probabilistic inference tasks.

1.1 Social information in decision-making

Humans have a strong predisposition toward socially transmitted information (Rendell et al., 2011). People often attribute a unique value to social information and pay more attention to it than to non-social information irrespective of it being communicated by real, human individuals or simply being framed as social (Collins et al., 2011; Önkal, Goodwin, Thomson, Sinan, & Pollock, 2009; Prombeger & Baron, 2006; Wærn & Ramberg, 1996). For instance, people tend to trust social information more than factual information coming from a non-social source such as information generated by a statistical method. In

this vein, Promberger and Baron (2006) found that people were more likely to follow the recommendation of a social source compared to the recommendation of a computer algorithm. A similar study (Wærn & Ramberg, 1996) showed that the reported trust in social sources was much higher compared to non-social ones. Moreover, participants more often attributed positive characteristics such as insight and explanatory value to advice coming from a social source than they did to a non-social source.

From an evolutionary perspective a preference for social information can be very beneficial: Following social information is adaptive because it removes the necessity to explore the problem environment by, for instance, time-consuming trial-and-error learning (Henrich & McElreath, 2003; McElreath et al., 2005; McElreath, Fasolo, & Wallin, 2010). Indeed, if another person has already invested a substantial effort to solve a problem, acquiring this information through imitation or advice can be a cheap and relatively effortless alternative (Grüter et al., 2010), especially so when it is difficult or costly to explore an environment and gather firsthand experience (Henrich & Boyd, 1998; Henrich & McElreath, 2003; McElreath et al., 2005). This suggests that people could have a predisposition towards considering social information, which can influence how much they rely on this information when searching for information and when making judgments and decisions. In line with this idea, Collins et al. (2011) found in a classification task that when social and non-social information was provided simultaneously, people considered social information even if it did not provide any additional insight. Conversely, when both pieces of information were of the same type, the redundant piece of information was ignored (see also De Houwer, Beckers, & Vandorpe, 2005). Similarly, Önkal et al. (2009) showed that in a forecasting task, advice stemming from a human expert received more attention than advice from a forecasting algorithm. Furthermore, the advice coming from a social source had a longer-lasting effect on forecasts.

Nevertheless, people do not exclusively rely on social information (Franz & Matthews, 2010), but also consider information from other sources (e.g. Puskaric et al., 2016). Moreover, they sometimes underweight social information compared to non-social information (Weizsäcker, 2010; Yaniv & Kleinberger, 2000). This raises the question whether in a probabilistic inference task, in which people often need to deal with social and non-social information, denoting information as social will increase the probability that people search for this information and give it a greater weight in the decision process.

1.2 Information search in probabilistic inferences

Probabilistic inference refers to the process of inferring which of two or more options (e.g., different job candidates) has a higher value on a criterion (e.g., candidates' suitability for the open position) on the basis of a number of probabilistic cues (e.g., work experience, education, or skills). To explain how people make probabilistic inferences, current research has distinguished a multi-strategy and a single-strategy approach (Bröder & Eichler, 2006; Busemeyer & Townsend, 1993; Gigerenzer & Todd, 1999; Glöckner & Betsch, 2008; Hausmann & Läge, 2008; Lee & Cummins, 2004; Rieskamp, 2006; Rieskamp & Hoffrage, 2008). A multi-strategy or toolbox approach assumes that humans have a repertoire of strategies from which they choose the appropriate strategy depending on the demands of the decision task (Gigerenzer & Todd, 1999; Payne, Bettman & Johnson, 1993). Strategies can be broadly classified into compensatory and non-compensatory strategy types (e.g., Payne et al., 1993). Compensatory strategies such as the weighted additive strategy (WADD) assume that people make a decision by weighing and integrating all available information — which allows compensating low values on an important cue by high values on less important ones. In contrast, non-compensatory strategies such as the take-the-best strategy (TTB, Gigerenzer

& Goldstein, 1996) assume that people make a decision based only on the most valid, discriminating cue independent of the option's value on the other cues. Only when a cue does not discriminate, is the next most valid cue considered. Past research has shown that people can learn to select the best-performing strategy for a specific environment based on outcome feedback (Mata, von Helversen, & Rieskamp, 2010, 2011; Rieskamp, 2006; Rieskamp & Otto, 2006).

In contrast, the single-strategy approach assumes that decision makers employ a single decision-making mechanism that is adjusted to a given inference problem. Different models have been proposed to describe the decision processes within a single-strategy approach, with connectionist models and evidence accumulation models featured most prominently (Glöckner, 2009; Newell & Lee, 2011). These models capture the observed changes in behavior in compensatory or non-compensatory tasks via changes in model parameters. For instance, connectionist models assume changes in the weighting of cues (Glöckner & Betsch, 2008) and evidence accumulation models assume changes of decision thresholds (Hausmann & Läge, 2008; Lee & Cummins, 2004; Newell, 2005). In general, both single and multi-strategy frameworks have been shown to account well for empirical data. The current work does not aim to test both approaches against each other. Although we use a multi-strategy approach in the current paper, we use it purely as a tool to show how framing information as social compared to non-social may affect people's information search and their decisions.[1]

Past research has shown that people adapt their decision behavior to the features and demands of the task. In this vein, it has been shown that people search for less information and rely more frequently on non-compensatory strategies when time is scarce, information

[1] In a single-strategy framework the changes we observe in "decision strategies" would likely be reflected in the decision weights that the cues receive in the social compared to the non-social condition.

search is costly, and information needs to be searched or retrieved from memory, and when the cue validities differ strongly (Bröder, 2000; Bröder & Schiffer, 2003; Newell and Shanks, 2003; Newell, Weston, & Shanks, 2003; Rieskamp & Hoffrage, 2008; Rieskamp & Otto, 2006). In contrast, if all information is easily available, people have sufficient time, are in a positive mood, and validities are similar, people search for more information and rely more frequently on compensatory strategies (e.g., Bröder, 2000; Bröder & Schiffer, 2006; Payne, Bettman, & Johnson, 1988; Platzer & Bröder, 2012; Scheibehenne & von Helversen, 2014; Söllner & Hilbig, 2013). Furthermore, as well as highlighting different information during feedback, the design of the decision display can influence how people represent and solve the decision task (Bröder, Glöckner, Betsch, Link, & Ettlin, 2013; Söllner & Hilbig, 2013). Here, we aim to investigate whether framing the information about the decision options as social or non-social will also affect how people solve the decision task.

1.3 Social information in probabilistic inference tasks

So far, there is relatively little research on the use of social information in probabilistic inference tasks. Betsch and colleagues (Betsch & Lang, 2013; Betsch, Lang, Lehmann, & Axmann, 2014) found in a social decision-making task with children that when focusing attention on an advice giver (in this case, different animals) by calling it a personal friend, it increased how often the animal was asked for advice and how strongly the advice influenced the decision. Studies with adults have studied inferences using different types of tasks ranging from asking people to infer which cities have more inhabitants to which companies' stocks bring a higher profit, or which movies will attract more viewers. Although some of these studies have provided social cues such as advice from experts (e.g., Ettlin & Bröder, 2015; Scheibehenne & von Helversen, 2014) and others have provided non-social cues such as indicators of a company's past performance or information about a city's attributes (e.g., Rieskamp, 2006), to our knowledge no study has examined whether the social

nature of cues has a specific influence on the decision process.

However, there is research in probabilistic inference tasks suggesting that how people search for information in the environment is also guided by preexisting concepts about the cues (Garcia-Retamero & Dhami, 2009; Garcia-Retamero, Müller, Catena, & Maldonado, 2009; Garcia-Retamero, Wallin, & Dieckmann, 2007). Accordingly, if people are predisposed to give social information a higher weight than non-social information this might influence how often they search social compared to non-social information as well as the weight this information receives in the decision process. In the following we report two studies to test this hypothesis.

2 Study 1

In Study 1 participants solved a probabilistic inference task in which they had to infer which of two options had a higher criterion value on the basis of six cues that were probabilistically related to the criterion. Using a within-subject design we compared whether framing all cues as non-social information in comparison to framing only half of the cues as non-social information and framing the other half as social information changed how often the cues were considered and which option was chosen.

3 Methods

3.1 Participants

Forty participants (23 female, 17 male) with an average age of 25.1 (range 21 - 45 years) took part in the experiment. We excluded the data of two participants from the analysis: one because the experiment had to be terminated prematurely due to technical difficulties and one because the participant did not look up a single cue during the task. The duration of the experiment was approximately 30 min.

3.2 Design and materials

Participants had to solve a probabilistic inference task, where they had to decide which of the two potential job candidates, labeled A and B, would be more suitable for a job. They made 60 decisions and in each comparison one of the candidates was more suitable for the position. Participants could evaluate the job applicants on the basis of six different cues. A positive value on a given cue indicated that the job candidate was more suited to the job. Participants were told that by considering the cues, they could increase their chance of making a correct inference beyond chance level. The experimental design had one within-subject factor: The source of information varied between trials. In half of the trials, participants were provided with solely non-social information (non-social trials), representing different skills of the candidates. In the other half of the trials, the same 30 items were presented but three of the six cues were framed as social information, representing the advice of hypothetical colleagues of the participant (social trials). To make the task more immersive, detailed information about the cues was provided. For instance, it was explained why a certain skill is valuable for the job or why a certain piece of advice is useful. The non-social cues were (from the most valid to the least valid): Computer skills, mathematical skills, organizational skills, manual skills, communication skills, and writing skills. The corresponding validities of the cues (0.79, 0.70, 0.65, 0.61, 0.56, and 0.53) were provided to the participants and were visible during the whole experiment (see Fig. 1). We implemented the social cues in the form of advice from three colleagues of varying expertise, reflected in varying cue validities of 0.65, 0.61, and 0.56. The concept of cue validities was explained to participants: They were told that by adhering to a cue with a validity of, for instance, 0.65 they would make a correct inference in 65 of 100 cases where this cue discriminates between the two candidates. A summary of the items used in the study can be found in the Appendix A in Table A1. The items set was identical to the non-compensatory item set of Study 1 from Rieskamp (2006), which was generated by applying an optimization algorithm (i.e., a genetic

algorithm) according to following specifications: The items fulfilled the requirement that the two strategies — weighted additive (WADD) and take-the-best (TTB) — made unambiguous inferences for every item. Second, for half of all items both strategies made identical predictions and for the other half they made different predictions. Third, TTB reached an accuracy of 83% and WADD reached an accuracy of 60%. Fourth, the cue validities should be above 50% and should differ by at least 2 percentage points. Fifth, the validities of the cues should be similar in both item sets.

Recently, Jekel and Glöckner (2016) argued for an alternative way of specifying the weights of WADD, so that cues with a relatively low validity should be given much less weight. It is of course possible that alternative ways of specifying a decision strategy will improve how well the strategy can describe people's decisions. However, in the present work we do not aim for testing the two strategies against each other. In contrast, we solely examined whether information presented as social or non-social changes whether people make non-compensatory or compensatory decisions and use the two strategies as labels for the decision behavior.

In each trial, participants could look up the information of all six cues by clicking on the corresponding icon. All cues and their validities were presented at the top of the screen (see Fig. 1). The order in which the cues were presented on the screen varied randomly in each of the first 30 trials. In the second block of 30 trials, the cue order was matched with the corresponding order in the first block. For 15 items of the first block, three cues were given a social framing (i.e., labeled as the advice of colleagues) and the remaining 15 cues were framed as non-social. In the second block, the framing order of items containing social and non-social cues was reversed. To distinguish the different types of framing, social cues had a green border and non-social cues a blue border. When a cue was selected, the corresponding values were shown for both job candidates simultaneously. After a cue was selected, the

participant had to wait approximately 1 s until the next cue could be selected and the mouse was returned to the center of the screen. The order in which the information about the job candidates appeared on the lower half of the screen was determined by the order in which the cues were selected by the participant. The cue information either was provided in the form of an X indicating that the candidate did not possess the corresponding skill, or was not advised by the colleague. In contrast, a check mark indicated that the candidate either possessed the skill or was recommended by the corresponding colleague. Participants could decide at any time during the trial that they had searched for enough information and make a decision by clicking on the corresponding job candidate. Participants were told that throughout the whole experiment, no feedback would be provided. At the end of the experiment they would be told the number of correct inferences made and the total amount of money they had won.

3.3 Procedure

Participants first provided informed consent to participate in the study. They were instructed to infer the better job candidate on the basis of six cues. After finishing the task, participants received either 10 Swiss francs or course credit. Additionally, participants could gain a bonus of up to 12 Swiss francs, depending on their performance: For each correct answer they received 0.20 Swiss francs, for each incorrect answer 0.20 Swiss francs were deducted from the bonus. The task was performed on a computer using the software "E-Prime" (Psychology Software Tools Inc., Sharpsburg, USA).

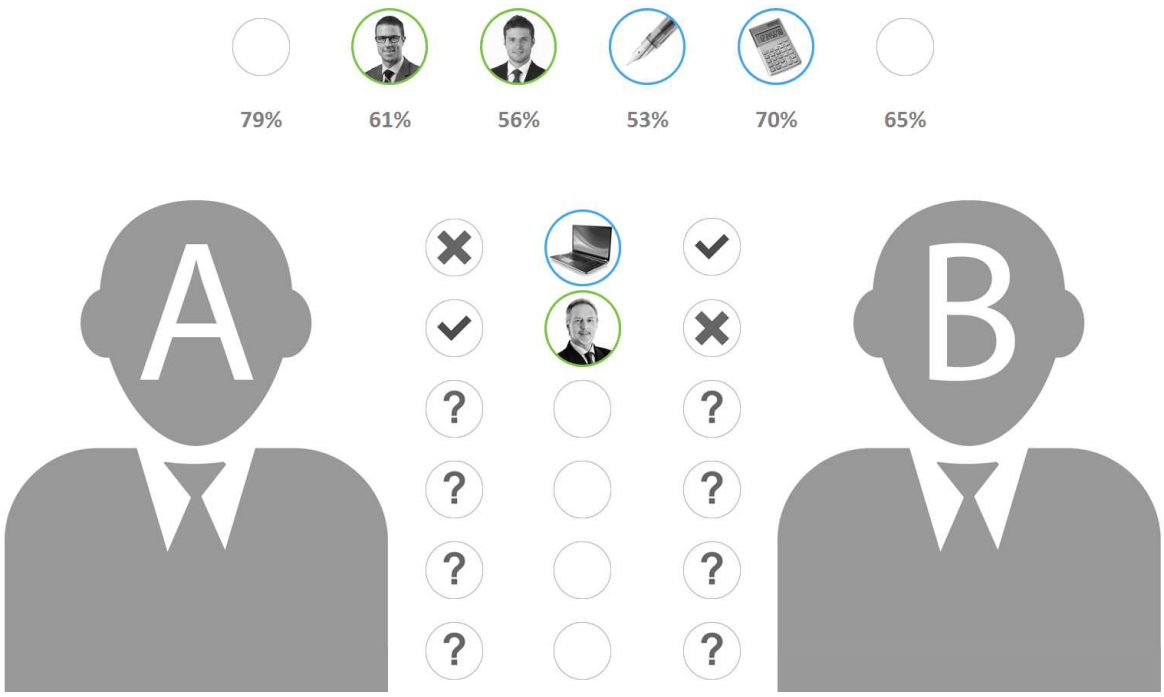

Fig. 1 Screenshot of the task in the social information trials. The available cues and the corresponding validities were displayed in random order above the two options A and B. Already selected cues were displayed sequentially in the column between option A and B.

4 Results

In the following, we first report the impact of the information framing on information search and thereafter the analysis of participants' decisions.

4.1 Information search

First, participants' information search was strongly influenced by the validities of the cues. Most important, the social framing also influenced the information search: The three cues that were framed as either social or non-social were looked up more frequently when they were framed as social. Table 1 summarizes the average percentage of trials each cue was searched for. Fig. 2 summarizes the changes in search from the non-social to the social

condition. On average participants searched for 4.2 (*SD* = 0.9) cues in the non-social trials compared to 4.3 (*SD* = 0.9) in the social trials.

Table 1

Cue search behavior in Study 1.

	Non-Social Trials		Social Trials	
	M	SD	M	SD
Cue 1	98.1%	5.2	95.5%	13.9
Cue 2	96.2%	7.9	90.1%	18.3
Cue 3*	83.9%	19.4	91.6%	14.0
Cue 4*	59.1%	30.4	67.9%	26.1
Cue 5*	45.1%	28.9	48.6%	26.9
Cue 6	38.3%	28.2	36.5%	26.2

Note. The table shows the average percentage of trials each cue was searched for differentiated for non-social and social trials in Study 1. In the table the cues are sorted according to their validity, with cue 1 being the most valid cue and cue 6 the least valid cue. The three cues marked with * were framed as social or non-social depending on the experimental condition.

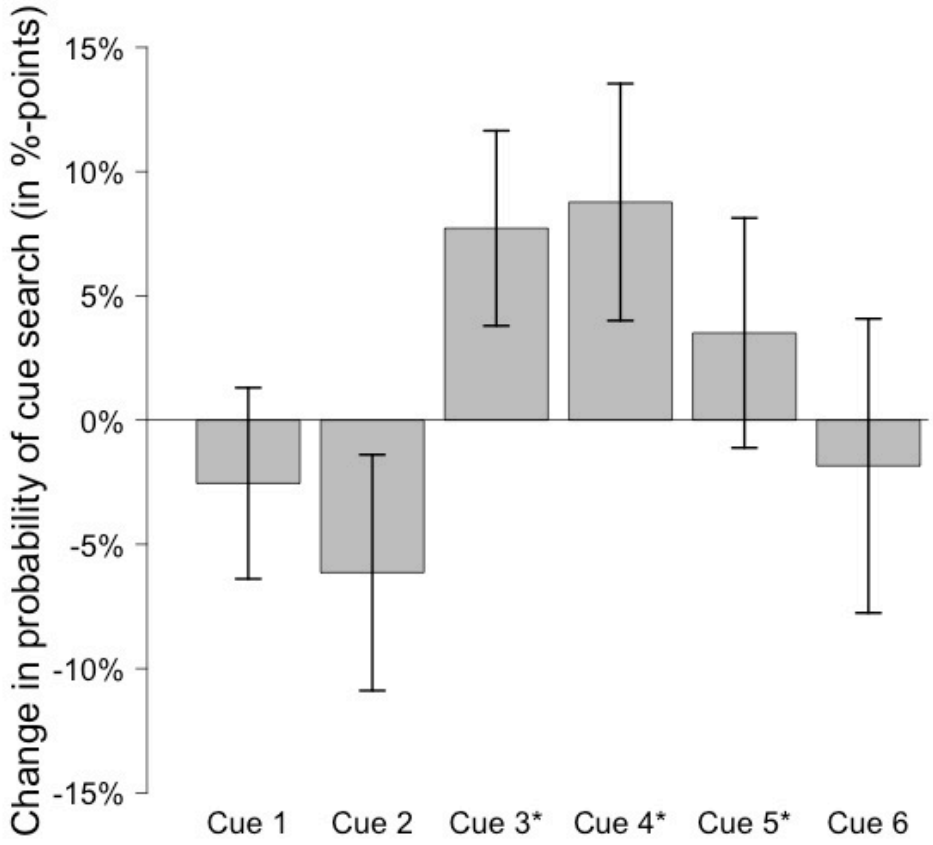

Fig. 2 Difference in how often a cue was acquired in the social condition as compared to the non-social condition. The tree cues marked with * were framed as social or non-social depending on the experimental condition. The remaining three cues were always framed as non-social information. Error bars depict 95% confidence intervals.

To assess the statistical effect of social versus non-social framing on search behavior, we performed a logistic mixed effects analysis comparing cue use between social and non-social trials using the r package lme4 (Bates, Maechler, Bolker, & Walker 2015). We use logistic mixed effects analysis in favor of a traditional ANOVA approach, as it is designed for binomially distributed outcomes (see Jaeger, 2007), whereas the ANOVA is intended for continuous data and leads to issues when analyzing data that are inherently categorical (Agresti, 2002).

We compared four models of increasing complexity: a) a null model only including an intercept and random effects (intercepts) for subjects and items (*AIC* = 15,120); b) a model containing in addition a fixed factor trial type denoting whether a trial contained social cues or only non-social cues (*AIC* = 15,117); c) a model containing in addition the fixed factor cue type indicating whether a cue was always framed as non-social information or changed frames between conditions (*AIC* = 14,941); d) a model containing in addition to the factors in model c the interaction between the fixed factors trial type and cue type (*AIC* = 14,896). *P*-values were obtained by using chi-square tests to compare the fit between the respective models. The analyses showed that including trial type led to a small increase in fit over the null model, $X^2(1) = 4.63$, $p = 0.03$, indicating that participants looked up slightly more cues in the social than in the non-social trials. Adding cue type in the analysis also increased model fit, $X^2(1) = 178.27$, $p < 0.001$, suggesting that on average the non-social cues were sampled more often than the social cues — probably reflecting their higher validity. Finally, including the interaction of trial type and cue type again improved model fit compared to the model without interaction, $X^2(1) = 46.68$, $p < 0.001$, suggesting that the between-trial manipulation affected social and non-social cues differently. More specifically, in trials where social and non-social information were combined, the three social cues were 1.45 times more likely to be looked up compared to the trials in which only non-social cues were shown. Conversely, the three non-social cues were 1.23 times more likely to be considered in the non-social than the social trials. Table 2 summarizes the parameter estimates of the statistically best model.

Table 2

Analysis of search behavior and decision strategy in study 1.

Predictor	Coef.	SE	Odds Ratio

Information search	Intercept	1.42	0.15	4.18
	Cue type (0 = Non-social; 1 = Social)	-0.81	0.06	0.44
	Trial type (0 = Non-social; 1 = Social)	-0.21	0.06	0.81
	Trial type × Cue type	0.55	0.08	1.74
Decision strategy	Intercept	0.46	0.26	1.59
	Trial type (0 = Non-social; 1 = Social)	-0.03	0.13	0.97

Note: Coefficients, standard error, and odds ratios of the statistically best models in experiment 1. $N = 38$.

4.2 Decision strategies

Because participants did not receive any feedback and the correctness of the different choice options was only constrained by the prediction of the two strategies TTB and WADD, the analysis of the performance is less meaningful. Nevertheless, the participants made on average 73.9% (*SD* = 6.5) correct choices in the non-social trials and 72.2% (*SD* = 6.4) correct choices in the social trials.

To assess whether the different social framing also affected the strategy that people selected for their decisions, we determined how well TTB predicted participants' choices, focusing on the items where the two strategies made different predictions. Descriptive data showed a general preference for TTB, but no effect of the framing of the cues: In the non-social trials participants made on average 60.4 % (*SD* = 12.7) choices corresponding to TTB and 39.6 % (*SD* = 12.7) corresponding to WADD. In the social trials the ratio was 59.8 % (*SD* = 12.4) for TTB and 40.2 % (*SD* = 12.4) for WADD. This result was supported by a logistic mixed effects analysis testing whether trial type (social vs. non-social) influenced how frequently TTB predicted participants' choices. Comparing a model with the factor trial type (*AIC* = 1381) to a null model (*AIC* = 1383; containing an intercept and random

intercepts for subjects and items) showed that including trial type did not lead to a better prediction of TTB, $X^2(1) = 0.04$, $p = 0.84$ (see Table 2 for a summary of the model).[2]

In sum, the results show that the social versus the non-social framing of the information had a strong effect on how the participants searched for the different cues, with social cues being acquired more often. However, the social versus the non-social framing did not influence the strategy participants employed: In trials where social cues were present, the participants were equally likely to use a non-compensatory strategy as when no social cues were present.

5 Discussion of Study 1

The goal of Study 1 was to investigate how framing information as social or non-social influences the way people make inferences. We found that cues of medium validity had a higher probability of being searched when framed as social than as non-social information. These results resonate with previous work showing that social information receives more attention (Collins et al., 2011; Önkal et al. 2009; Promberger & Baron, 2006; Wærn & Ramberg, 1996). Furthermore, in terms of information search they dovetail with related work in probabilistic inference showing that putting a cue in the focus of attention, for instance by manipulating its salience, increases the probability that it is looked up and will affect which option is chosen (Betsch et al., 2014; Betsch & Lang, 2013; Platzer & Bröder, 2012). However, in contrast to these studies the framing manipulation did not lead to a significant change in decision-making behavior. Participants chose the option consistent with a non-compensatory decision strategy with a similar probability in the non-social and social information trials. One reason why the changes in search behavior did not translate into a

[2] In addition, we ran an analysis that also included which cue discriminated first. This analysis indicated no significant influence of this factor on strategy choice and did not change the results of trial type.

change in decisions could be that we presented participants with the correct validities, which may have led them to the same decisions even if the information was looked up differently — thus limiting the framing effect. Indeed, some research suggests that social information is often considered in a confirmatory fashion and not necessarily taken as independent evidence (e.g., Collins et al., 2011; Schrah, Dalal, & Sniezek, 2006). This resonates with findings showing that people consider social information, but still put more weight on non-social information in situations when the quality of social information is low or uncertain (Biele, Rieskamp & Gonzales, 2009; Luan, Sorkin, Itzkowitz, 2004; Yaniv & Kleinberger, 2000).

If participants' knowledge of the validities reduced a potential social framing effect, then the effect of social information may be stronger if people do not know the exact validities of the cues. To test this hypothesis, we conducted a second study in which we did not inform participants about the cue validities but used a learning paradigm in which participants received feedback about their decisions.

In addition, we changed which cue was highlighted by social information. One limitation of Study 1 is that the effect of social framing is confounded by the diversity of the cues: In the social condition, cues stemmed from different sources of information whereas in the non-social condition all cues were from the same source of information. Diversity in the cues has been shown to lead to more information search and an increased use of compensatory decision strategies (Dieckmann & Rieskamp, 2007; Harkins & Petty, 1987). Accordingly, it is possible that diversity, rather than the social nature of the cues, caused the increase in information search. To disentangle the effect of diversity from the effect of framing information as social, in the second study we framed the most valid cue as social — and not cues of medium validity as in Study 1. If social information indeed receives more attention, participants should focus more on the most valid cue in this task leading to fewer cues being searched and more reliance on non-compensatory strategies in the social condition

than in the non-social condition. In contrast, according to the diversity hypothesis, participants should search for more cues and be more likely to rely on compensatory strategies in the social condition, because in this condition the cues stem from more diverse sources.

Furthermore, the effect of framing information as social or non-social in Study 1 could be confounded by the visual presentation of cues: In the social condition, the social cue was made visually distinct form non-social cues by presenting it in a green colored box, whereas non-social cues were presented in blue boxes. The effects of visual presentation on information search and decision strategies in probabilistic inference are still ambiguous: A study by Platzer and Bröder (2012) has shown that presenting cues in a pictorial instead of verbal format influences the retrieval of cues from memory, which in turn had an effect on the decision-making strategy people employed. In contrast, a study by Ettlin and Bröder (2015) shows that grouping of cues by means of color or special proximity has no effect on information search or decision strategy people employ.

6 Study 2

The goal of Study 2 was (1) to investigate whether framing information as social may not only influence search but also affect decisions if participants do not know the cue validities, (2) to disentangle the effects of diversity and social information, and (3) to control for confound effects elicited by grouping social and non-social cues by color. Using a non-compensatory decision task (i.e., a task in which using a non-compensatory strategy is adaptive), we examined whether framing the most valid cue as social would facilitate learning in order to reduce search and to use a non-compensatory strategy in two experiments: Study 2A and 2B.

In Study 2 A, participants again had to solve a paired inference task based on six

probabilistic cues that were all framed either as non-social information or as containing social and non-social information. In contrast to Study 1, we used a between-subject design, with a non-social condition in which all six cues were framed as non-social information and a social condition in which the most valid cue was presented as advice from a colleague. In Study 2 B we aimed to replicate results from Study 2 A and controlled for the possible influence of color on how people approach the decision task: Participants solved an identical paired inference task with the exception that we did not use color to distinguish between the social and non-social type of cues.

7 Methods: Study 2 A

7.1 Participants

Forty participants (27 female, 13 male) with an average age of 23.6 (range 18 – 49 years) took part in the experiment; 20 participants were assigned randomly to each condition. The duration of the experiment was approximately 25 min. All participants received course credit for participation.

7.2 Design

Participants had to solve a similar probabilistic inference task to that in Study 1. Here the goal was to decide which of two firms would perform better. The task consisted of the same 30 items as in Study 1 (see Table A1 in the Appendix A), which were repeated in four blocks resulting in a total of 120 trials. The sequence of the items was randomly determined in each block. In each comparison one of the options was better. The experimental design had one between-subject factor: In the non-social condition, all cues stemmed from the same source (non-social information) whereas in the social condition the first cue was framed as advice from a coworker and the other five cues as non-social information. Participants could evaluate the firms on the basis of six different cues. The most valid cue was labeled

"efficiency" in the non-social and "advice" in the social condition (0.79), the second valid cue "financial resources" (0.70), the third valid cue "financial flexibility" (0.65), the fourth valid cue "capital structure" (0.61), the fifth valid cue "management" (0.56), and the sixth valid cue "qualifications of employees" (0.53). A positive cue value indicated that the firm possessed this characteristic and was more likely to perform better. Participants were told that by considering the cues, they could increase their chance of making a correct inference above guessing level. As illustrated in Fig. 3, the cues were depicted at the center of the screen, one column containing the cue names and two columns containing cue information for the respective objects, with the social cue having a green border and non-social cues a blue one. The cue validities were not disclosed to the participants, but cues were ordered according to their validities. We ordered cues according to their validities to reduce the complexity of the task and to focus on the number of cues people would search. The cue values of both firms were hidden initially and could only be uncovered in the order of their cue validities. When a cue was selected, the corresponding values were uncovered for both firms simultaneously. The cue information either was provided in the form of an X indicating that the firm did not have the corresponding feature, or in the case of advice, was not advised. Conversely, a check mark indicated that the firm either possessed the feature or was recommended by the advisor. Participants could decide at any point in the trial that they had searched for enough information and make a decision by clicking on the company logo. After each decision participants received feedback whether their decision had been correct. At the end of the experiment they were told the number of correct inferences they had made and total number of points they had won.

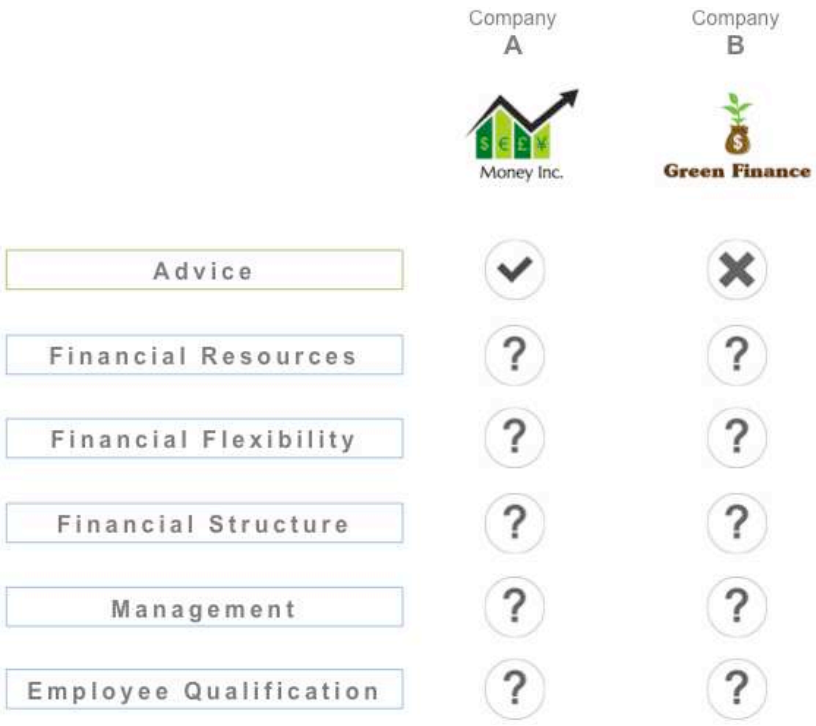

Fig. 3 Screenshot of the task in the social condition. In the situation depicted, the participant has already uncovered the first cue. Cues were sequentially ordered according to their validity and had to be searched in that order. No cue validities were displayed.

7.3 Procedure

Participants first received a consent form printed on paper, in which they agreed to participate in the study. Participants were instructed to infer the better firm on the basis of the cues provided. After finishing the task, participants received participation credit for attendance. Additionally, participants could gain a total bonus of 120 points; for every 20 points participants had accumulated by the end of the task, they gained 1 piece of candy. The task was performed on a computer using the software "E-Prime" (Psychology Software Tools Inc., Sharpsburg, USA).

8 Results: Study 2 A

We again analyzed whether framing all information as non-social (non-social condition) or framing the most valid cue as social information (social condition) influenced information search and decisions.

8.1 Information search

In both conditions, participants searched for fewer cues over the course of the task. In the non-social condition participants searched 5 (*SD* = 1.0) cues on average in the first block and 4.3 (*SD* = 1.1) in the last block. In the social condition the change was from 5.4 (*SD* = 0.7) in the first block to 4 (*SD* = 0.9) searched cues in the last block. Fig. 4 summarizes the behavioral results with the number of cues searched per block shown in panel A.

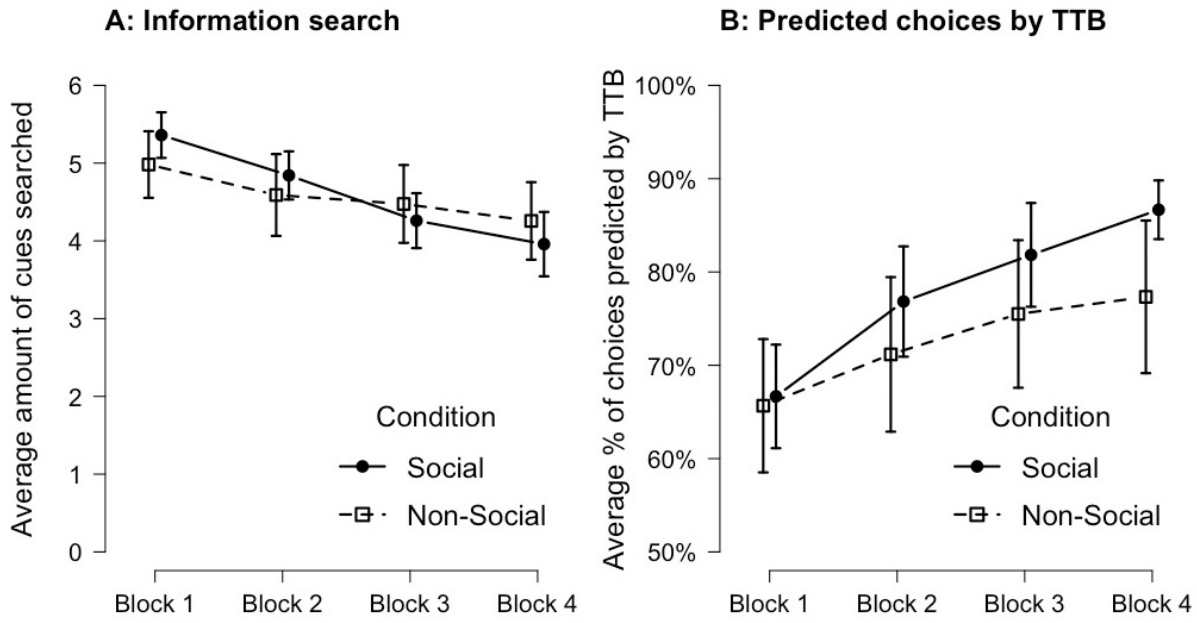

Fig. 4 Left panel (A) depicts the average number of cues searched and the right panel (B) shows the percentage of choices in line with the prediction of a non-compensatory strategy TTB over the course of the task for Study 2 A. Error bars depict 95% confidence intervals.

We performed a linear mixed effects analysis to compare the number of cues searched between the conditions, with condition, block (centered) and their interaction as fixed factors and random effects for participants (intercept and slopes for block) and items (intercept and slopes for condition and block) using the fitlme function of the statistics and machine learning toolbox in matlab 2017a (® mathworks) and the Satterthwaite correction for degrees of freedom. The analyses shows a significant effect of block, F (1, 38.27) = 11.73, p = 0.001, no effect of condition, F(1, 38.10) = 0.01, p = 0.92, and a significant interaction between block and condition, F(1, 38) = 7.02, p = 0.01. As illustrated in Fig.4 panel A, this indicates that overall participants looked up fewer cues over the curse of the task, but participants in the social condition showed a steeper decline in the number of cues they searched for than participants in the non-social condition (see Table 3 for a summary of the fixed effects).

Table 3

Analysis of search behavior and decision strategy in study 2 A.

	Predictor	Coef.	SE	Odds ratio
Information search	Intercept	4.58	0.19	-
	Block	-0.23	0.07	0.79
	Condition (0 = non-social; 1 = social)	0.03	0.27	1.03
	Condition × Block	-0.25	0.09	0.78
Decision strategy	Intercept	1.71	0.39	-
	Block	0.29	0.12	1.34
	Condition (0 = non-social; 1 = social)	0.80	0.38	2.23
	Condition × Block	0.04	0.17	1.04

8.2 Decision strategy

To investigate participants' decision strategies we compared the frequency of choices in line with the prediction of the TTB strategy in the two conditions. Choice concordance

with the TTB strategy increased from 65.7% (*SD* = 16.3) to 77.3% (*SD* = 18.7) from the first to the last block of the non-social condition and from 66.7% (*SD* = 12.7) to 86.7% (*SD* = 7.1) in the social condition. To assess whether the social framing of cues had an effect on strategy use, we performed a logistic mixed effects analysis examining the frequency with which participants decided in line with the prediction of TTB with the same fixed and random effects structure.[3] The analysis showed significant effects of block, $t(4796) = 2.45$, $p = .01$, and condition, $t(4796) = 2.13$, $p = .03$, but no interaction, $t(4796) = 0.22$, $p > 0.82$, see Table 3. This shows that participants learned to adapt their decisions to the non-compensatory nature of the environment in both tasks, but when the most valid cue was framed as social information participants were in general more likely to rely on a non-compensatory strategy.

Consistent with accelerated choices in line with the prediction of the TTB strategy, the percentage of correct decisions also increased from 68.0% (*SD* = 8.9) to 72.0% (*SD* =12.4) from the first to the last block of the non-social condition and from 69.3% (*SD* = 8.9) to 78.5% (*SD* = 5.9) in the social condition. Similarly, statistical analyses using whether the decision was correct or not as dependent variable also found a strong effect of condition, $b = 1.05$, $SE = 0.27$, $t(4796) = -3.84$, $p < .001$, suggesting that participants in the social condition performed better, but no effect of block and no interaction of block and condition (all *p*s > .35).

9 Methods: Study 2 B

9.1 Participants

Ninety participants (62 female, 28 male) with an average age of 25.2 (range 18 – 54 years) took part in the experiment; 45 participants were assigned randomly to each condition. One participant was excluded due to aborting the task prematurely and four because they did

[3] In this model we also included random slopes for the interaction of condition and block, a model that did not converge for the number of cues sampled. A model with the reduced random effects structure (i.e. just containing random slopes for the main effects of condition and block) showed similar results as the full model.

not search for any information in more than 80% of the trials in the last block; the duration of the experiment was approximately 25 min. All participants received course credit for participation.

9.2 Design

Participants had to solve the same probabilistic inference task as in Study 2 A, with the exception that cues were presented without a colored border that would distinguish social cues from non-social cues.

9.3 Procedure

Participants first received a consent form printed on paper, in which they agreed to participate in the study. Participants were instructed to infer the better firm on the basis of the cues provided. After finishing the task, participants received participation credit for attendance or a show-up fee of 15 Swiss francs. Additionally, participants could gain a total bonus of 120 points; for every 20 points participants accumulated by the end of the task, they gained 1 Swiss franc. The task was performed on a computer using the software "*E-Prime*" (Psychology Software Tools Inc., Sharpsburg, USA).

10 Results: Study 2 B

Akin to Study 2 A we analyzed whether framing all information as non-social (non-social condition) or framing the most valid cue as social information (social condition) influenced information search and decisions. We excluded all trials in which participants did not search for any information from the analysis (about 2% of the trials).

10.1 Information search

In both conditions, participants searched fewer cues over the course of the task. In the non-social condition participants searched 5.2 (SD = 1.4) cues on average in the first block and in the last block. In the social condition the change was from 5.5 (SD = 1.2) in the first

block to 5.3 (*SD* = 1.4) searched cues in the last block. Fig. 5 summarizes the behavioral results with the number of cues searched per block shown in panel A.

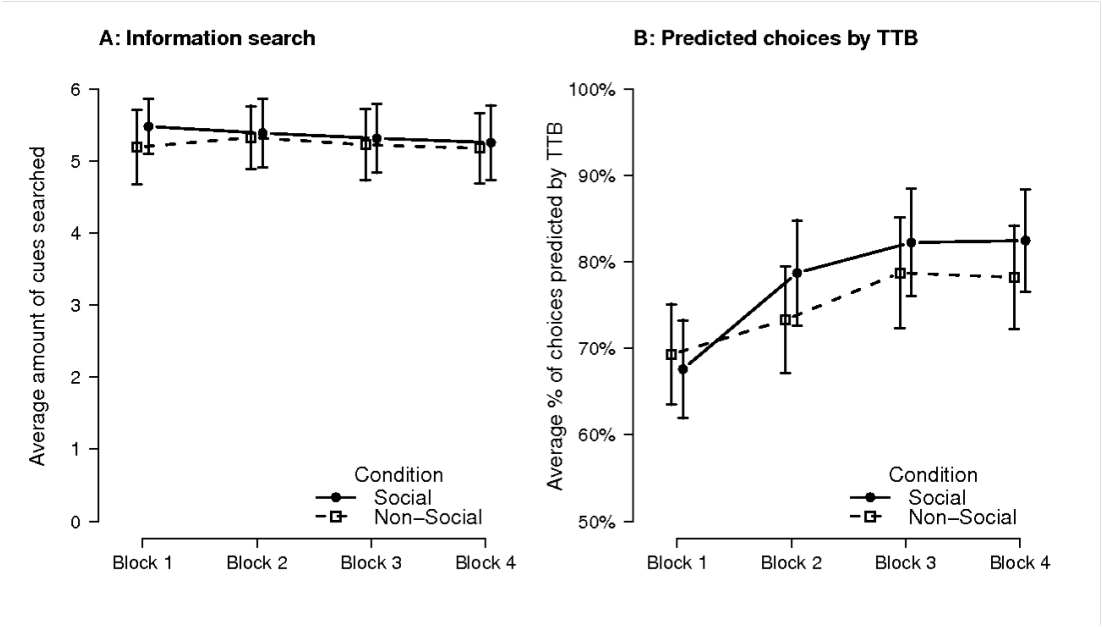

Fig. 5. Left panel (A) depicts the average number of cues searched and the right panel (B) shows the percentage of choices in line with the prediction of a non-compensatory strategy TTB over the course of the task in Study 2 B. Error bars depict 95% confidence intervals.

We performed again a linear mixed effects analysis to compare the number of cues searched between the conditions.[4] We found no effect of block, $F(1, 83.85) = 1.71$, $p = 0.19$, condition, $F(1, 83.96) = 0.37$, $p = 0.54$, or their interaction, $F(1, 83.88) = 0.52$, $p = 0.47$, on the number of cues searched for suggesting that the number of cues participants searched did not change over the course of the experiment and did not depend on the condition they were in. See Table 4 for a summary of the full model.

Table 4

[4]The model did not contain random slopes for items because the model including them indicated that they did not vary resulting in convergence problems. Otherwise the same fixed and random effects as in the analyses for Study 2A was used.

Analysis of search behavior and decision strategy in study 2 B.

	Predictor	Coef.	SE	Odds ratio
Information search		5.36	0.15	-
	Block	-0.07	0.06	0.93
	Condition (0 = non-social; 1 = social)	-0.13	0.21	0.88
	Block × Condition	0.06	0.08	1.06
Decision strategy	Intercept	2.13	0.36	-
	Block	0.42	0.08	1.52
	Condition (0 = non-social; 1 = social)	0.03	0.27	1.03
	Block × Condition	-0.28	0.11	0.76

10.2 Decision Strategy

Over the course of the task, participants in both conditions increasingly adapted to the decision environment and used a non-compensatory strategy more frequently. Choice concordance with the predictions of the TTB strategy increased from 69.3 % (*SD* = 13.3) to 78.2% (*SD* = 13.7) from the first to the last block of the non-social condition and from 67.6% (*SD* = 12.9) to 82.5% (*SD* = 13.5) in the social condition. To assess the effect of framing on decision making, we performed a logistic mixed effects analysis with the same effects structure as in Study 2A examining the frequency with which participants decided in line with the prediction of TTB. We again found a main effect for block $t(10136) = 5.04$, $p < .001$, suggesting that participants adapted to the non-compensatory nature of the environment. In contrast to Study 2A we did not find a main effect of condition, $t(10136) = 0.11$, $p = 0.91$, but instead a significant interaction between block and condition, $t(10136) = -2.64$, $p = 0.008$, suggesting that when a cue that was framed as social information participants learned faster and to adapt their decisions to the non-compensatory nature of the environment (see Table 4).

Likewise, the percentage of correct decisions also increased, from 70.1% (*SD* = 8.3) in the first block to 77.6% (*SD* = 8.5) in the last block in the non-social condition and from 70.2% (*SD* = 9.5) to 77.3% (*SD* = 10.3) in the social condition. Statistical analyses with the percentage of correct decisions as dependent variables showed an effect of block as fixed factor but no effect of social condition and no interaction of block and condition.

11 Discussion of Study 2

The goal of Study 2 was threefold: First, we aimed to investigate whether the effect of social information may generalize to decisions where validities were not provided and participants had to learn to adapt their search and decision strategy to the task by feedback. Second, we wanted to test whether the effects of social information in Study 1 were indeed caused by social information receiving special attention and not by the increased diversity of information in the social condition (Dieckmann & Rieskamp, 2007; Harkins & Petty, 1987). Third, we aimed to control for the effect of visual presentation of cues, which could have led to potential confounds of social framing by making particular cues more salient.

In both studies participants searched for fewer cues over time and made more decisions in line with a non-compensatory strategy. This overall learning effect reflects previous research showing that people adapt their decision behavior to the learning environment leading to less search and more use of TTB in tasks where non-compensatory strategies are more advantageous (Mata, von Helversen, & Rieskamp, 2010, 2011; Rieskamp & Otto, 2006; Rieskamp, 2006). In addition to the main effect of block we found an interaction between condition and block in Study 2 A, indicating that while search decreased in both conditions, this learning process was stronger in the social as compared to the non-social condition. That is, when the most valid cue was presented as social information participants learned faster to rely on this cue and to ignore the other cues than when it was

framed as non-social information. However, we did not find that framing a cue as social affected information search in Study 2 B, in which all cues received the same color code. This suggests that highlighting the social cue with another color was important for participants to reduce their search. These results deviate from findings by Ettlin and Bröder (2015) suggesting little impact of visual presentation on information search. Accordingly, it is possible that the combination of social framing with visually highlighting the framed cues is important to find effects on information search.

Notably, the effects of framing a cue as social on the decision strategy were independent of whether cues were highlighted by color or not. In Study 2 A we found that overall participants in the social condition made more non-compensatory decisions than participants in the non-social condition. In Study 2 B participants in the social condition learnt faster to adapt a non-compensatory strategy than participants in the non-social condition. This indicates that social cues received larger weight in the decision process — independent of whether they were highlighted by color and how many cues were searched. These results resonate with previous findings (Ettlin & Bröder, 2015), which suggests that visual presentation by grouping of cues through the use of color and spatial proximity has negligible effects on strategy use.

Regarding the question of whether the diversity of the cues or the social framing has a more important influence on cue search, the findings clearly support the idea that social information receives more attention (e.g., Collins et al. 2011; Önkal et al., 2009). Moreover, our findings resonate with previous literature suggesting that social cues can reduce search, because they enable decision makers to discover and to focus on the relevant information more quickly (Denrell & Le Mens, 2007; Heyes, 2012; Önkal et al. 2009). Nevertheless, in the first block participants tended to search somewhat more in the social than the non-social

condition, suggesting that diversity could have played a role in the beginning of the task and may have contributed to the findings of Study 1.

Lastly, given that in our task reliance on a non-compensatory strategy was adaptive, social information also increased performance. This finding is consistent with a large body of literature, which shows that social information supports learning and can lead to better learning outcomes (Biele, Rieskamp, & Gonzalez, 2009; Grüter, Leadbeater, & Ratnieks, 2010; Heyes, 2012; McElreath et al., 2005; Morgan, Rendell, Ehn, Hoppitt, & Laland, 2012; Rendell et al., 2010; Rendell et al., 2011). However, it should be noted that the beneficial effects of social information could be limited to situations where the effect of social information matches the structure of the task. Thus it is possible that framing the most valid cue as social might hinder learning in a compensatory decision task.

12 General discussion

The current work examined how framing information as social or non-social affects decision making in a probabilistic inference paradigm. Comparing decision tasks in which all cues were framed as non-social information to tasks where some of the cues were framed as social and some as non-social information, we found that in Study 1 framing medium validity cues as social information increased the probability that they were looked up, but did not lead to more compensatory decisions. In Study 2 — where we did not inform participants about the cues validities but used a learning paradigm — framing a high-validity cue as social information facilitated focusing on this most valid cue and also led to more adoption of a non-compensatory decision strategy. The effect is carried by framing of the cues, irrespective of the visual presentation of the cues. This suggests that framing information as social can increase the probability that the information will be looked up, but whether the information also influences decisions may depend on the weight people give the information. Here, our

findings indicate that framing information as social does not override information about the cues validities, but can impact behavior if people do not know the validities for sure — as may often be the case in real decision environments (Yaniv, 2004). Furthermore, our findings show that whether framing information as social increases or decreases information search, reliance on non-compensatory strategies, and performance, will depend on the cues that are enhanced by social framing and the structure of the decision task. To the degree that highlighting information by framing it as social matches the structure of the task, it could be a tool to improve decision making by drawing attention to the important cues.

The results of all three studies resonate with research suggesting that social information commands unique attention in human decision makers (Mesoudi et al., 2006), and as such is perceived as qualitatively different from non-social cues (Collins et al., 2011; Önkal et al. 2009; Puskaric et al., 2016; Promberger & Baron, 2006; Wærn & Ramberg, 1996). In addition, they correspond to related work showing that manipulating the attention that decision makers give to cues can change how people search for information and also influence the decisions they make in probabilistic inferences (Betsch et al., 2014; Betsch & Lang, 2013; Ettlin & Bröder, 2015; Platzer, Bröder, & Heck, 2014; Platzer & Bröder, 2012; Söllner & Hilbig, 2013) and related paradigms (Collins et al., 2011; Önkal et al., 2009).

12.1 Future research

Future studies should examine how social information specifically influences the decision-making process in inference problems. In the current paper we focused on examining whether social information leads more likely to a non-compensatory decision process in a very broad sense. It is a topic of ongoing research to understand how particular strategies are influenced by the inclusion of social information or whether social information in probabilistic inference can be better understood when following a single process view such as sequential sampling models (e.g., Rakow, Newell, Fayers & Hersby, 2005).

12.2 Conclusion

In sum, the two studies show that framing cues as social information can change how these cues are treated in the decision process. The studies suggest that social cues receive more attention than non-social cues and outline when and how framing cues of high or medium validity as social will influence information search and choice. In this vein, our research integrates research on information framing in probabilistic inference and social influence, demonstrating how the unique quality of social information can change the ways humans search and use information for their decisions.

References

Agresti A., Categorical data analysis, 2002, John Wiley & Sons; New York, NY.

Bates D., Mächler M., Bolker B. and Walker S., Fitting linear mixed-effects models using lme4, *Journal of Statistical Software* **67** (1), 2015, 1–48, https://doi.org/10.18637/jss.v067.i01.

Betsch T. and Lang A., Utilization of probabilistic cues in the presence of irrelevant information: A comparison of risky choice in children and adults, *Journal of Experimental Child Psychology* **115** (1), 2013, 108–125, https://doi.org/10.1016/j.jecp.2012.11.003.

Betsch T., Lang A., Lehmann A. and Axmann J.M., Utilizing probabilities as decision weights in closed and open information boards: A comparison of children and adults, *Acta Psychologica* **153**, 2014, 74–86, https://doi.org/10.1016/j.actpsy.2014.09.008.

Biele G., Rieskamp J. and Gonzalez R., Computational models for the combination of advice and individual learning, *Cognitive Science* **33** (2), 2009, 206–242, https://doi.org/10.1111/j.1551-6709.2009.01010.x.

Bröder A., Assessing the empirical validity of the "take-the-best" heuristic as a model of human probabilistic inference, 26 (Experiment 1), 2000, 1332–1346, https://doi.org/10.1037//0278-7393.26.5.1332.

Bröder A. and Eichler A., The use of recognition information and additional cues in inferences from memory, *Acta Psychologica* **121**, 2006, 275–284, https://doi.org/10.1016/j.actpsy.2005.07.001.

Bröder A., Glöckner A., Betsch T., Link D. and Ettlin F., Do people learn option or strategy routines in multi-attribute decisions? The answer depends on subtle factors, *Acta Psychologica* **143** (2), 2013, 200–209, https://doi.org/10.1016/j.actpsy.2013.03.005.

Bröder A. and Schiffer S., Take the best versus simultaneous feature matching: Probabilistic inferences from memory and effects of representation format, *Journal of Experimental Psychology: General* **132** (2), 2003, 277–293, https://doi.org/10.1037/0096-3445.132.2.277.

Bröder A. and Schiffer S., Stimulus format and working memory in fast and frugal strategy selection, *Journal of Behavioral Decision Making* **19** (4), 2006, 361–380, https://doi.org/10.1002/bdm.533.

Busemeyer J. and Townsend J., Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment, **100** (3), 1993, 432–459.

Collins E.C., Percy E.J., Smith E.R. and Kruschke J.K., Integrating advice and experience: Learning and decision making with social and nonsocial cues, *Journal of Personality and Social Psychology* **100** (6), 2011, 967–982, https://doi.org/10.1037/a0022982.

De Houwer J., Beckers T. and Vandorpe S., Evidence for the role of higher order reasoning processes in cue competition and other learning phenomena, *Learning & Behavior* **33** (2), 2005, 239–249.

Denrell J. and Le Mens G., Interdependent sampling and social influence, *Psychological Review* **114** (2), 2007, 398–422, https://doi.org/10.1037/0033-295X.114.2.398.

Dieckmann A. and Rieskamp J., The influence of information redundancy on probabilistic inferences, *Memory & Cognition* **35** (7), 2007, 1801–1813, https://doi.org/10.3758/BF03193511.

Drehmann M., Oechssler J. and Roider A., Herding with and without payoff externalities — An internet experiment, *International Journal of Industrial Organization* **25** (2), 2007, 391–415, https://doi.org/10.1016/j.ijindorg.2006.04.016.

Ettlin F. and Bröder A., Perceptual grouping does not affect multi-attribute decision making if no processing costs are involved, *Acta Psychologica* **157**, 2015, 30–43, https://doi.org/10.1016/j.actpsy.2015.02.002.

Franz M. and Matthews L.J., Social enhancement can create adaptive, arbitrary and maladaptive cultural traditions, *Proceedings of the Biological Sciences/The Royal Society* **277** (June), 2010, 3363–3372, https://doi.org/10.1098/rspb.2010.0705

Garcia-Retamero, R., & Dhami, M.K., Take-the-best in expert–novice decision strategies for residential burglary. *Psychonomic Bulletin & Review*, **16** (1), 2009, 163–169. https://doi.org/10.3758/PBR.16.1.163

Garcia-Retamero R., Wallin A. and Dieckmann A., Does causal knowledge help us be faster and more frugal in our decisions?, *Memory & Cognition* **35** (6), 2007, 1399–1409, https://doi.org/10.3758/BF03193610.

Gibson S., Social learning (cognitive) theory and implications for human resource development, *Advances in Developing Human Resources* **6** (2), 2004, 193–210, https://doi.org/10.1177/1523422304263429.

Gigerenzer G. and Goldstein D.G., Reasoning the fast and frugal way: Models of bounded rationality, *Psychological Review* **103** (4), 1996, 650–669 https://doi.org/doi.org/10.1037/0033-295X.103.4.650.

Gigerenzer G. and Todd P.M., Simple heuristics that make us smart. Simple heuristics that make us smart, 1999, Oxford University Press; New York.

Glöckner A., Investigating intuitive and deliberate processes statistically: The multiple-measure maximum likelihood strategy classification method, *Judgment and Decision making* **4** (3), 2009, 186–199.

Glöckner A. and Betsch T., Multiple-reason decision making based on automatic processing, *Journal of Experimental Psychology: Learning, Memory, and Cognition* **34** (5), 2008, 1055–1075, https://doi.org/10.1037/0278-7393.34.5.1055.

Grüter C., Leadbeater E. and Ratnieks F.L.W., Social learning: The importance of copying others, *Current Biology: CB* **20** (16), 2010, R683–5, https://doi.org/10.1016/j.cub.2010.06.052.

Harkins S.G. and Petty R.E., Information utility and the multiple source effect, *Journal of Personality and Social Psychology* **52** (2), 1987, 260–268, https://doi.org/10.1037/0022-3514.52.2.260.

Hausmann D. and Läge D., Sequential evidence accumulation in decision making: The individual desired level of confidence can explain the extent of information acquisition, *Judgment and Decision making* **3** (3), 2008, 229–243.

Henrich J. and Boyd R., The evolution of conformist transmission and the emergence of between-group differences, *Evolution and Human Behavior* **19** (4), 1998, 215–241, https://doi.org/10.1016/S1090-5138(98)00018-X.

Henrich J. and McElreath R., The evolution of cultural evolution, *Evolutionary Anthropology: Issues, News, and Reviews* **12** (3), 2003, 123–135, https://doi.org/10.1002/evan.10110.

Heyes C., What's social about social learning?, *Journal of Comparative Psychology (Washington, D.C.: 1983)* **126** (2), 2012, 193–202, https://doi.org/10.1037/a0025180

Jaeger, T. F., Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language* **59** (4), 2008, 434 – 446. https://doi.org/10.1016/j.jml.2007.11.007

Jekel, M., and Glöckner, A., How to Identify Strategy Use and Adaptive Strategy Selection: The Crucial Role of Chance Correction in Weighted Compensatory Strategies. *J. Behav. Dec. Making,* 2016, doi: 10.1002/bdm.1983.

Lee M.D. and Cummins T.D.R., Evidence accumulation in decision making: Unifying the "take the best" and the "rational" models, *Psychonomic Bulletin & Review* **11** (2), 2004, 343–352.

Luan, S., Sorkin, R.D., & Itzkowitz, J., Weighting information from outside sources: A biased process. *J. Behav. Dec. Making* **17**, 2004, 95 – 116.

Mata R., von Helversen B. and Rieskamp J., Learning to choose: Cognitive aging and strategy selection learning in decision making, *Psychology and Aging* **25** (2), 2010, 299–309, https://doi.org/10.1037/a0018923.

Mata R., von Helversen B. and Rieskamp J., When easy comes hard: The development of adaptive strategy selection, *Child Development* **82** (2), 2011, 687–700, https://doi.org/10.1111/j.1467-8624.2010.01535.x.

McElreath R., Fasolo B. and Wallin A., The evolutionary rationality of social learning, In: *Simple heuristics in a social world,* 2010, 1–33.

McElreath R., Lubell M., Richerson P.J., Waring T.M., Baum W., Edsten E., … Paciotti B., Applying evolutionary models to the laboratory study of social learning, *Evolution and Human Behavior* **26** (6), 2005, 483–508.

Mesoudi A., Whiten A. and Dunbar R., A bias for social information in human cultural transmission, *British Journal of Psychology (London, England: 1953)* **97** (Pt 3), 2006, 405–423, https://doi.org/10.1348/000712605X85871.

Morgan T.J.H., Rendell L.E., Ehn M., Hoppitt W. and Laland K.N., The evolutionary basis of human social learning, *Proceedings of the Royal Society B: Biological Sciences* **279** (1729), 2012, 653–662, https://doi.org/10.1098/rspb.2011.1172.

Newell, B.R., Re-visions of rationality? *Trends in Cognitive Sciences* **9**, 2005, 11-15

Newell B.R. and Lee M.D., The right tool for the job? Comparing an evidence accumulation and a naive strategy selection model of decision making, *Journal of Behavioral Decision Making* **24** (20), 2011, 456–481, https://doi.org/10.1002/bdm.

Newell B.R. and Shanks D.R., Take the best or look at the rest? Factors influencing "one-reason"decision making, *Journal of Experimental Psychology: Learning, Memory, and Cognition* **29** (1), 2003, 53–65, https://doi.org/10.1037/0278-7393.29.1.53.

Newell B.R., Weston N.J. and Shanks D.R., Empirical tests of a fast-and-frugal heuristic: Not everyone "takes-the-best", In: *Organizational Behavior and Human Decision Processes,* **91**, 2003, 82–96, https://doi.org/10.1016/S0749-5978(02)00525-3.

Önkal D., Goodwin P., Thomson M., Sinan G. and Pollock A., The relative influence of advice from human experts and statistical methods on forecast adjustments, *The*

Journal of Behavioral Decision Making **22**, 2009, 390–409, https://doi.org/10.1002/bdm.637.

Payne J.W., Bettman J.R. and Johnson E.J., Adaptive strategy selection in decision making, *Journal of Experimental Psychology. Learning, Memory, and Cognition,* 1988, https://doi.org/10.1037/0278-7393.14.3.534.

Payne J.W., Bettman J.R. and Johnson E.J., Contingencies in decision making, In: *The adaptive decision maker,* 1993, Cambridge University Press, 20–33, https://doi.org/10.2307/2235352.

Platzer C. and Bröder A., Most people do not ignore salient invalid cues in memory-based decisions, *Psychonomic Bulletin & Review* **19** (4), 2012, 654–661, https://doi.org/10.3758/s13423-012-0248-4.

Platzer C., Bröder A. and Heck D.W., Deciding with the eye: How the visually manipulated accessibility of information in memory influences decision behavior, *Memory & Cognition* **42** (4), 2014, 595–608, https://doi.org/10.3758/s13421-013-0380-z.

Promberger M. and Baron J., Do patients trust computers?, *Journal of Behavioral Decision Making* **468**, 2006, 455–468, https://doi.org/10.1002/bdm.

Puskaric, M., von Helversen, B., Rieskamp, J., How social and non-social information influence classification decisions: A computational modelling approach. *The Quarterly Journal of Experimental Psychology* **70** (8), 2017, 1516-1534.

Rakow T., Newell B.R., Fayers K. and Hersby M., Evaluating three criteria for establishing cue-search hierarchies in inferential judgment, *Journal of Experimental Psychology: Learning, Memory, and Cognition* **31** (5), 2005, 1088–1104, https://doi.org/10.1037/0278-7393.31.5.1088

Rendell L., Boyd R., Cownden D., Enquist M., Eriksson K., Feldman M.W., … Laland K.N., Why copy others? Insights from the social learning strategies tournament, *Science (New York, N.Y.)* **328** (5975), 2010, 208–213, https://doi.org/10.1126/science.1184719.

Rendell L., Fogarty L., Hoppitt W.J.E., Morgan T.J.H., Webster M.M. and Laland K.N., Cognitive culture: Theoretical and empirical insights into social learning strategies, *Trends in Cognitive Sciences* **15** (2), 2011, 68–76, https://doi.org/10.1016/j.tics.2010.12.002.

Rieskamp J., Perspectives of probabilistic inferences: Reinforcement learning and an adaptive network compared, *Journal of Experimental Psychology. Learning, Memory, and Cognition* **32** (6), 2006, 1355–1370, https://doi.org/10.1037/0278-7393.32.6.1355.

Rieskamp J. and Hoffrage U., Inferences under time pressure: How opportunity costs affect strategy selection, *Acta Psychologica* **127** (2), 2008, 258–276.

Rieskamp J. and Otto P.E., SSL: A theory of how people learn to select strategies, *Journal of Experimental Psychology: General* **135** (2), 2006, 207–236.

Scheibehenne B. and von Helversen B., Selecting decision strategies: The differential role of affect, *Cognition & Emotion* **0** (0), 2014, 1–10, https://doi.org/10.1080/02699931.2014.896318.

Schrah G.E., Dalal R.S. and Sniezek J.A., No decision-maker is an Island: Integrating expert advice with information acquisition, *Journal of Behavioral Decision Making* **19**, 2006, 43–60, https://doi.org/10.1002/bdm.514.

Smith E.R. and Collins E.C., Contextualizing person perception: Distributed social cognition, *Psychological Review* **116** (2), 2009, 343–364, https://doi.org/10.1037/a0015072

Söllner, A., Bröder, A. & Hilbig, B. E., Deliberation versus automaticity in decision making: Which presentation format features facilitate automatic decision making? *Judgment and*

Decision Making **8** (3), 2013, 278-298.

Sommerfeld R.D., Krambeck H.-J., Semmann D. and Milinski M., Gossip as an alternative for direct observation in games of indirect reciprocity, *Proceedings of the National Academy of Sciences of the United States of America* **104** (44), 2007, 17435–17440, https://doi.org/10.1073/pnas.0704598104.

Wærn Y. and Ramberg R., People's perception of human and computer advice, *Computers in Human Behavior* **12** (1), 1996, 17–27.

Weizsäcker G., Do we follow others when we should? A simple test of rational expectations, *American Economic Review* **100** (5), 2010, 2340–2360, https://doi.org/10.1257/aer.100.5.2340.

Yaniv I., Receiving other people's advice: Influence and benefit, *Organizational Behavior and Human Decision Processes* **93** (1), 2004, 1–13, https://doi.org/10.1016/j.obhdp.2003.08.002.

Yaniv I. and Kleinberger E., Advice taking in decision making: Egocentric discounting and reputation formation, *Organizational Behavior and Human Decision Processes* **83** (2), 2000, 260–281, https://doi.org/10.1006/obhd.2000.2909.

Appendix A

Table A1

Overview of items used in Study 1 and Study 2

	Option A						Option B								
Item	Cue 1	Cue 2	Cue 3 *	Cue 4 *	Cue 5 *	Cue 6	Cue 1	Cue 2	Cue 3*	Cue 4*	Cue 5*	Cue 6	Correct	TTB	WADD
1	0	0	0	1	0	1	0	1	1	0	1	1	B	B	B
2	0	1	1	1	0	1	0	0	1	0	0	0	A	A	A
3	0	0	0	1	0	1	1	0	0	0	0	0	B	B	A
4	1	0	0	0	0	1	0	1	1	1	1	1	A	A	B
5	1	1	1	0	1	1	1	0	0	0	1	0	A	A	A
6	1	1	0	0	0	0	0	1	1	1	0	1	A	A	B
7	1	0	0	1	0	0	0	0	1	1	1	1	A	A	B
8	1	0	1	0	0	1	0	1	1	1	1	1	A	A	B
9	1	0	0	0	1	1	1	1	1	1	0	0	B	B	B
10	1	0	0	0	1	1	1	1	0	1	1	1	B	B	B
11	1	0	0	0	0	1	1	1	1	1	0	1	B	B	B
12	0	1	1	1	0	0	1	0	1	0	0	0	A	B	A
13	1	0	0	0	1	0	1	1	1	1	1	0	B	B	B
14	0	1	1	1	1	1	1	1	0	1	0	0	A	B	A

18	0	1	0	0	0	0	0	1	1	1	1	0	B	B	B
19	1	0	0	0	0	1	0	0	1	1	1	1	A	A	B
20	0	1	0	1	1	1	1	1	0	0	1	0	B	B	A
21	1	0	1	1	1	1	1	1	0	1	1	0	A	B	A
22	0	1	1	0	0	1	0	1	0	1	1	1	B	A	B
23	1	0	0	0	0	0	1	1	1	0	1	1	B	B	B
24	0	0	0	0	1	0	0	1	1	1	1	1	B	B	B
25	0	1	0	0	1	1	1	0	0	1	0	0	B	B	A
26	1	0	0	0	0	0	0	0	1	0	1	0	A	A	B
27	1	1	1	1	1	0	1	0	0	0	0	0	A	A	A
28	0	1	0	1	0	1	1	0	1	0	0	0	B	B	A
29	1	1	1	1	0	1	1	0	0	0	0	1	A	A	A
30	0	1	1	1	0	1	1	0	0	1	0	1	B	B	A

Note: Items used in both studies. A cue value 1 signifies that the option has the (positive) feature while a 0 indicates that it does not. All items have been presented twice and in random order within each block for a total of 60 trials. The cues marked with an * were presented as social information on every second trial.